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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication
of
Motor Vehicles
[Effects of Neglect]

Fuel Oil in a Skyscraper

PUBLISHED MONTHLY BY
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This broken connecting rod was the result of a piston which seized at high speed because the lubricating oil had been too greatly diluted with fuel. Notice that the lower bearing is still in perfect condition.

Lubrication of Motor Vehicles

The Effects of Neglect

THE technical importance of automobile racing to engineers lies in the fact that the vital weakness of any mechanical device can be picked out only by pushing it to its utmost limit. There are many machines which will stand up in ordinary service but fall down when subjected to an emergency overload, which will always come sooner or later. This is one of the reasons for the difficulty experienced in developing reliable airplane engines, the service required of them continuously being more severe than that of racing automobile engines during their fastest spurts. One of the principal lessons learned from all racing and airplane development has been the fundamental importance of lubrication. Its neglect is certain to result in rapid wear and eventual failure. The life of any mechanism is limited by "old age" just as surely as is human life, the length of service rendered before "old age" develops being a question of wear, and wear is a question of lubrication. It is only by systematic inspection during the service of even the most perfectly constructed machine, that one can be sure that something may not have interfered with the proper lubrication, which will reveal itself only after the wear has already occurred.

Periodic Inspection as a Preventative of Trouble

For this reason, in service where maximum reliability is essential, such as that of railroads and airplanes, the mechanical equipment is given a careful inspection at definite periods *before* trouble is expected to develop. These periods are determined by long experience as the shortest time the mechanism may be depended upon to operate without danger to service. Inspection is then made without waiting for trouble to develop. It is a common sense application of the principle of prevention. A good example of this type of inspection is presented by the routine of a certain well-organized motor-bus transportation company, where every vehicle is given an inspection covering fuel, oil, water, etc., each morning, a general overhaul covering lubrication in detail, carbon removal, spark plugs, bearings, valves,

etc., after each 2,000 miles, and a complete disassembly and re-building each year, which represents approximately 30,000 miles. Those familiar with airplane engine maintenance during the war will recognize the similarity of the above to the daily preliminary inspection, the more thorough inspection after 10 hours or so, the "top overhaul" and finally the complete overhaul after 50 to 100 hours, depending on the type of engine. It is only by means of such precautions that failure can be minimized in service, and the effectiveness of such measures is very apparent to anyone who knows how rarely the equipment of the bus company just mentioned ever breaks down on the streets.

Operators of commercial vehicles, and pleasure car owners, are only beginning to realize the saving of expense and avoidance of annoying delays which will result from a similar application of the principle of inspection for trouble before trouble occurs. This beginning is represented by the annual overhaul of automobiles and trucks which has now become quite common at this season of each year. Since so many users of automobile equipment are now getting their vehicles into condition for the summer, and are making the necessary repairs and replacements of worn parts, it will probably be of particular interest at this time to call attention to some typical examples of the conditions which may be found during this inspection, and show the reasons for them, as well as suggest ways by which they could have been prevented. It is such common knowledge that machinery must always be lubricated and many operators are so sure they know the whole story that it is difficult to impress upon them how very far-reaching may be the results of giving the attention to this important subject that it deserves. Probably over three-quarters of all the parts replacements made on motor vehicles are of the nature of those described in this article, and are the results of improper lubrication. They are not necessarily the result of imperfect design nor of the use of the wrong lubricant to start with.

The various parts of a motor vehicle where the principal results of neglected lubrication occur, will be taken up in their usual order,—the engine, gear box, rear axle and chassis.

How Fuel Gets into Oil

To begin with the engine: a new factor in its maintenance has developed during the last few years because the very volatile fuel used prior to that time is no longer available in sufficient quantities to supply the tremendous demands of the present day motoring public, who consumed 4,178,000,000 gallons last year in the United States alone. The fuel now available is not as volatile, though it is superior with respect to the power obtainable per gallon. If this fuel is to be burned properly in modern engines, it must be vaporized to an extent which demands heating the mixture of fuel and air to well over 100° F. During cold weather, starting with this fuel is often almost impossible unless "priming" is resorted to, by which is meant the addition of an excessive amount of liquid fuel to the cylinder, either by pouring it in through pet cocks or by "choking" the carburetor. A little of the fuel vaporizes at the temperature of the cold engine, and if enough is vaporized, starting is possible, but most of the fuel remains unvaporized and has a tendency to wash the lubricating oil from the cylinder walls. Priming and driving with a choked carburetor should be resorted to as little as possible, and when it is done the engine should never be run at more than moderate speed until fresh lubricating oil has had time to work up on the cylinder walls to replace that which has been washed off by the liquid fuel. Figure I shows a piston from a motor truck, which seized and scored the cylinder as well as itself, simply because of excessive priming.

FIG. I.—A scored piston from a motor truck, due to excessive priming. The spots around the two small oil drainage holes have become blue with heat showing that the drainage of oil was too complete.

During the time a cold engine is running while it is warming up, the temperature of the fuel mixture is not high enough to vaporize completely the fuel from the carburetor, with the result that some of it enters the cylinders as drops of liquid fuel, which are thrown out toward the cylinder walls by the swirling, turbulent motion of the mixture as it rushes into the cylinders. Those drops of fuel which touch the cylinder walls mix readily with the film of lubricating oil there, making it so fluid that it works down past the piston rings and into the crank-case. In this way fuel accumulates in the oil in the crank case from every start when cold, and as some cars are driven during the winter without any attempt to prevent the radiator from keeping the engine too cool, the mixture for months at a time is too cold to vaporize completely and liquid fuel continues to get into the crank-case oil as long as the engine runs.

Another cause of rapid dilution is the operation of an engine with one or more cylinders "missing." As none of the fuel is burned in the "missing" cylinders, the effects of wet fuel just referred to are much aggravated.

Effect of Fuel in the Lubricating Oil

It does not require much fuel mixed with oil to make it so thin that it has almost no value as a lubricant. A sample of oil used for barely a month in a well-known eight-cylinder car, during very cold weather, was examined recently and found to contain so much fuel that it was over twenty times as fluid as the original oil. The reason for this excessive dilution was that the thermostat in the cooling system was not operating properly and the water jacket after an hour's run was barely warm enough to feel comfortable to one's hand. In Fig. II is shown the distillation curve for this sample of used oil. The particular class of lubricating oil originally used does not start to distill at temperatures below about 600° F., and since 50% of the used oil distilled below this temperature, it is assumed that no more than the remaining 50% was lubricating oil. In order to show that the oil remaining after 600° F., was practically identical with the original oil, data for the latter is shown by crosses, to such a scale of percentage that the starting point, or 0%, will begin where the temperature of the used oil reached 600° F. In the same way complete distillation curves for gasoline and kerosene are compared with that part of the used oil which distilled below 600° F. Notice that the latter lies midway between the curves for pure gasoline and kerosene, and shows that the fuel in the oil was similar to gasoline deprived of three-quarters of its most volatile part. If the distillation had been discontinued at about 600° F., all the fuel would have been driven off, leaving good lubricating oil of as great a viscosity as when new. This is essentially the process now successfully used for "reclaiming" oils, except that steam is used because the same results are secured with lower temperatures. Thus it is seen that this dilution with fuel is not in any sense of the word a "breaking down" of the lubricating oil.

In order to determine the ill effect of running an engine with very dilute oil, a laboratory test was made, in which raw kerosene was deliberately added to the oil. The result is shown in the illustration on page 1. A piston seized while running at good speed and the power of the other five cylinders buckled up the connecting rod, broke it and forced the lower end through the crank-case several times before the engine could be stopped. The bearings,

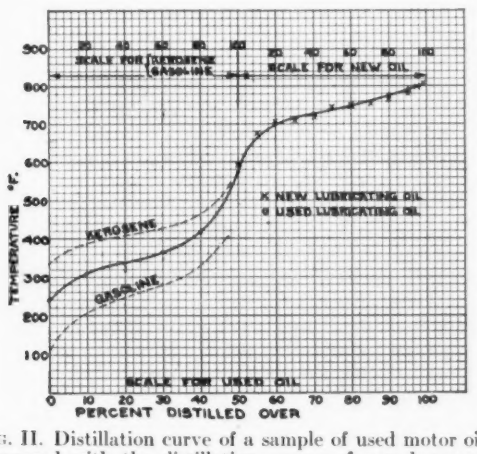


FIG. II. Distillation curve of a sample of used motor oil, compared with the distillation curves of new kerosene, gasoline, and lubricating oil, which shows that but 50% of this sample consisted of the original lubricating oil.

FIG. III. A "burned out" die-cast crank-shaft bearing; the result of running an engine with no oil at all on this bearing.

however, as can be seen, were not injured in the least.

Burned Out Bearings

When a bearing, which is known to be correctly designed like the specimen shown in Fig. III, is "burned out," there is but small chance that it was due to diluted oil. It will have been caused almost always by the fact that it got no oil at all, diluted or otherwise, and in addition to the resulting excessive heat of friction, the means of carrying off heat was interrupted. It must be remembered that oil in a high-speed engine serves a dual purpose of cooling the bearings as well as reducing their friction. When a bearing fails to get oil its temperature rises until it may actually melt, as did the one of Fig. III.

Four Causes for Bearing Failures

Bearing trouble in service is usually caused by allowing the oil level to get too low through inexcusable carelessness. In cold weather a similar effect may result if the oil is too cold to flow when the engine is started. This is another reason for warming a cold engine up slowly before using, for there are many oils on the market which thicken up like vaseline and will not flow at temperatures below the freezing point of water. In order to counteract the effects of sluggish or even congealed oil when starting a cold engine, engineers frequently recommend the use of a different oil in cold weather from that which is best for usual warm weather conditions.

A third cause for "burned out" bearings results when water gets into the crank-case and freezes around the oil pump. Water vapor is one of the products of combustion of gasoline, and if the pistons leak badly it will condense in the crank-case during cold weather. After standing some time the water separates to the lowest part of the oil sump, which is usually near the oil pump, and if it is cold enough to freeze, a broken oil pump may result when the engine is started, and of course, no oil can be pumped to the bearings.

There is still another possible cause for failure of oil to get to bearings. Solid matter, such as large chunks of carbon, but principally lint from cotton waste or rags used carelessly before re-assembling an engine, may easily clog the oil passages entirely, or at least stop up the inlet to the pump. Those engines which are lubricated by plunger pumps with ball or other automatic valves, are particularly liable to trouble because even fine sediment, if it lodges around the intake valve, will prevent delivery of oil.

Sediment and Wear

So far nothing else has been said about sediment. The mere fact that heat discolors any oil by precipitating fine carbon particles, has led many to believe that all sediment is some form of soft carbon which, of course, could do no harm as an abrasive. The fact that sediment may consist of good abrasive material was well illustrated by a test recently made at McCook Field on a Liberty airplane engine. Oil that had been used only ten hours was "centrifuged" to separate out all solid matter heavier than the oil. An examination of the sediment reveals a large amount of iron and steel which must have come from the piston rings and cylinders. A large percentage consisted of a very fine aluminum powder which must have come from the pistons. A small quantity of bronze powder was observed, also babbitt bearing metal. All of the above undoubtedly came from the working parts of the engine. Small chips, which resembled chips from machinery processes, were present; sand varying from very fine powder to small pebbles and carbon in various forms and sizes were also found. The sand was probably from the core sand that could not be cleaned out of the castings, and the carbon particles may have baked on the under side of the piston head and fallen off. There were also found small brown particles that looked like sand but would crush easily, and the conclusion was reached that these were made up of dust taken in through the breather. A motor vehicle, particularly a tractor, operating in air laden with dust, would show a much greater proportion of sandy grit than this. Quite a little would enter the engine with the air to the carburetor, and wear its way past the pistons, though of course this is almost unknown with airplane engines, or tests made indoors. Analysis of "carbon" removed from the combustion chambers of motor vehicles, shows the presence of silicon from fine sand.

Bearing Wear

Now all this solid matter is carried into the working parts of an engine by the circulation of the lubricating oil, and acts like an abrasive which is as sure in its action as emery, even if not as rapid. It is probable that it is almost the sole cause for bearing wear and a large factor in piston and cylinder wear. An experiment made by a large automobile engine manufacturer gives good evidence of this. An engine in good condition was run under load for sixty hours, the oil being drained frequently and replaced with new oil. When overhauled, the bearings showed no noticeable wear, and the

piston wear was not enough to measure. It was run again under the same conditions, but with dirty oil which had been drained from other engines after long use on the road. After only a few hours, wear had proceeded to such an extent that the engine became noisy in operation, and when again overhauled after sixty hours running there was enough wear to measure easily.

Removal of Diluted Oil and Sediment

How can the user of motor vehicles protect himself against these ill effects of fuel and grit in his oil? Simply by draining it all out at frequent intervals and replacing by fresh oil. Means have already been suggested for reducing the rate of dilution by fuel to a minimum, but it cannot be prevented entirely during the cold weather, and the slow wear of pistons and rings which mix metal dust with the oil, and the fine sandy dust which gets in from the air, can hardly be prevented. It is impossible, unfortunately, to give any definite rule as to how often the oil should be drained from the crank-case and replaced with new. The more often it is done the better, but while the cost of the oil is small when balanced against the cost of repairs and replacements of worn parts, there is a limit beyond which but little will be gained. As a general rule the change for an automobile or truck should be after about one thousand miles of ordinary driving, but if over very dusty roads, or during cold weather, particularly when short trips are made, this distance should be reduced to 400 or 500 miles, or once a week. A new engine, or one with newly re-bored cylinders, should be drained after the first 300 miles to remove the metal dust resulting from the first polishing of the new surfaces. It is usually considered good practice to wash the crank-case with kerosene after the old oil has been drained, since the sediment which remains behind is difficult to dislodge in any other way. A quart or two of kerosene agitated by spinning the engine for a few minutes is a very effective way of washing the crank-case thoroughly. The spinning should be done by hand if the engine is not provided with an electric starter to do this, but under no circumstances should the engine be run under its own power for this purpose. Sometimes the drain cocks are not placed so that all the kerosene can be drained from the crank-case, and it is very desirable to repeat the spinning with a little light motor oil which should be drained before adding the new oil.

Gear Boxes

The gear box and rear axle are parts which give so little trouble that usually they are almost forgotten by car users. Forgetfulness, however, has its price even with these reliable parts, as the accompanying illustrations show. Fig. IV shows a clash gear taken from the gear box of a motor vehicle used in heavy city traffic where over 600 accelerations are made each day. No lubricant can prevent teeth from

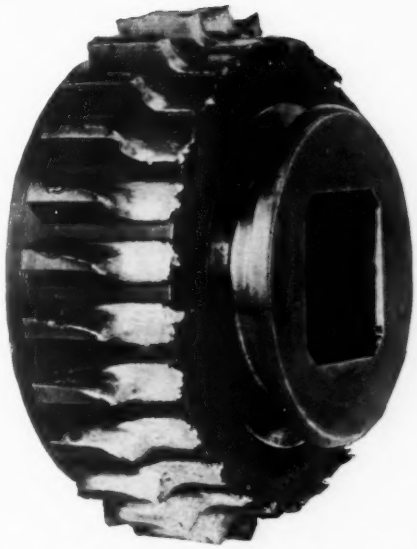


FIG. IV. A badly worn clash gear from a gear box which has seen heavy service. The metal which has worn away has gotten into the lubricating oil in the form of fine chips which makes a good abrasive.

FIG. V. This inner race and balls were taken from a ball bearing destroyed in service because of chips or other material getting into the ball races. The balls were blued by the resulting heat and welded to broken particles as can be seen.

chipping when they strike during gear changes, but the metal which is gone from the teeth got into the oil in the form of very fine chips of hard metal, which make a good abrasive. As gear oils and greases are very viscous they carry even fairly large chips with ease, and whenever the gears are in motion these chips will be repeatedly brought into the ball bearings and between the gear teeth. The ball-bearing of a 7-ton truck shown in Fig. V is an example of what can happen when chips get into it. The steel became so heated that some of the balls became welded to broken chips, and further destruction was avoided only when the inner race broke and by slipping on its shaft, acted like a plain bearing.

In the early days of automobile history gear boxes and axle housings were so poorly constructed in most instances that no lubricant could be prevented from leaking out except a stiff grease. Thus grease came into use for these parts not because it was the best lubricant for them but because it was the only lubricant that would stay. As time passed, details of motor vehicle construction improved, and since few gear boxes or housings will now allow a medium-bodied gear oil to leak out, the use of stiff grease is inexcusable and only due to mental inertia resulting from experience in the past. Such a grease is the best material in the world for suspending metal chips and holding them in dangerous proximity to the moving parts. The only way to be sure of preventing damage from them is first of all to use a lubricant fluid enough to allow the chips to settle to the bottom, and then make sure to remove them periodically by draining out the dirty oil and washing with kerosene. Those who have tried to clean out all the grease from a housing, will comprehend the difficulty of doing it thoroughly enough to remove all chips. In general, a gear box should be washed every 5,000 miles at least, and inspected for possible leakage more often.

Under certain conditions an unsuspectedly large amount of power is absorbed in the transmission merely by dragging the gears through a very viscous lubricant. To reduce this loss it is accepted practice not to fill the casing full of oil, but to maintain an oil level as low as possible and yet be sure each gear will be lubricated. Even with a low oil level, too viscous an oil should be avoided because there are bearings which are lubricated only by the oil splashed up to them. Generally speaking, ball bearings do not need much lubricant, but gear boxes and rear axles are often provided with roller bearings, which must be lubricated, as well as the plain bronze bearings frequently used in gear boxes and usually found in differentials.

Rear Axles

There are, unfortunately, a few rear axles now in use which are not tight enough to prevent a gear oil from leaking out at the wheel hubs, if it is as fluid as is desirable from the viewpoints just mentioned. There are several axles which will leak at the hubs if the oil level is too high, and aside from making the wheel unsightly the oil may get on the brakes and impair their holding power. But some axles will not hold oil even when the level is low enough, and in such instances there is danger of losing all the oil without knowing it, and running with unlubricated gears. This is bad in any case, but is disastrous with worm gears, and bronze worm wheels cost money. Bronze worm wheels, run dry for only a few hours, have been cut to such an extent that the teeth were actually stripped off. Even in ordinary service a worm wheel frequently wears considerably, and as soon as the wear starts the metal particles worn off when carried with the lubricant make a good abrasive and will accelerate the wear which supplies still more metal particles. Such unpleasant experiences as worm wheels ruined because of running dry can be avoided usually if the oil level is inspected at frequent intervals, and if the oil is low the leak may be caught in time and corrected by renewing the felt rings or other devices designed to prevent leakage.

Caution would direct the use in axles which are known to leak, either regularly or occasionally, of gear oils thick enough to leak slowly if at all. In rear axles, the use of a heavier oil than is desirable in gear boxes, even a "fluid grease," is not as serious because there are no clash gears to deposit chips in it and the loss of power from churning the oil is not as great. Yet it must not be forgotten that there are plain bronze bearings in almost all differentials, and oil must be fluid enough to get to them occasionally at least. The careful operator will inspect the oil level every thousand miles or so, particularly if the final drive is by worm.

Chassis Parts

Of all the moving parts of motor vehicles, the engine and transmission system receive the most attention to lubrication, because it is known that they cannot run long without some kind of lubricant. Since even these parts are often sadly neglected it is not surprising that universal joints, steering gears, drag links, spring shackles, brake rod clevises, starting motors, driving chains, and the like, are often almost forgotten. The large number of such parts requiring lubrication is evident from Fig. VI. This chart is supplied by one manu-

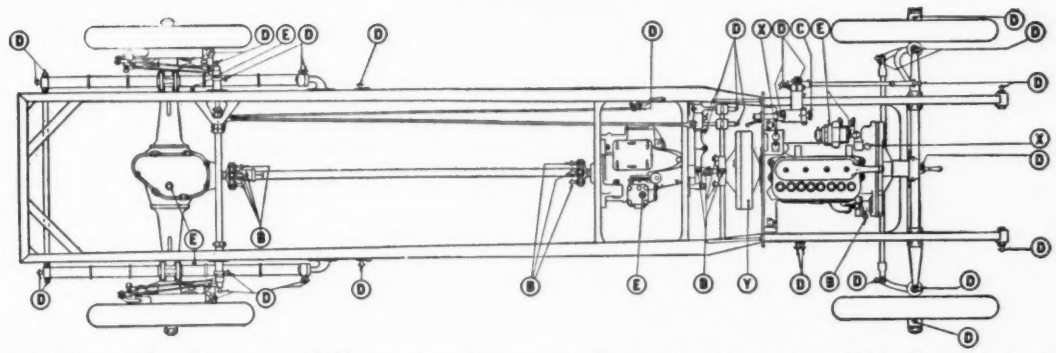


FIG. VI. An oiling diagram provided by an automobile manufacturer to assist the operators of his equipment to locate all the parts of the chassis which need particular attention to lubrication. He gives the following key to the letters used: (A) Oil daily; (B) grease daily; (C) oil weekly; (D) grease weekly; (E) oil monthly.

facturer and is typical of most chasses. It shows 59 places requiring lubrication, though over a dozen brake clevises and joints are not included. This number sounds large to the uninitiated but is not unusual, and if it is a surprise to the reader he can be reasonably sure that he has overlooked many such parts on his own car. Of course, it is a nuisance to care for all these parts regularly and attention

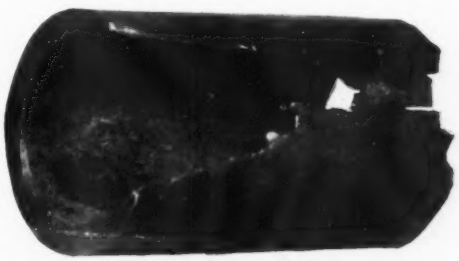


FIG. VII. This worn-out spring shackle bushing is characteristic of a large number of bushings throughout the chassis of any neglected car. This wear was probably accompanied in service by continual squeaking.

to them is often postponed almost indefinitely until it reaches the point of neglect, simply because the vehicle will run even when they are not lubricated. Yet is there anything that makes a good vehicle seem cheaper than that irritating squeaking which results? Whenever a squeaking vehicle passes on the street you can be safe in making a mental note that the driver is neglecting it and its second-hand value is falling needlessly. Squeaking is nothing less than a loud protest of neglected parts, as they are wearing out. Fig. VII shows typical unlubricated spring shackle bushings such as may be found in the junk box of any service station. It is similar to bushings all over a chassis the condition of which makes the chief difference between a vehicle in good condition and one that is "worn out." Bushings are not expensive, but the labor of replacing all the bushings and clevises in a car—re-building it—is expensive. Such parts are frequently lubricated by grease because of the high pressures and low rubbing velocities existing, and because it remains where it is wanted. The grease cups are often inaccessibly placed, and are a nuisance to fill, but patented types of grease guns and oil lubricators are now coming on the market, which make greasing a much simpler operation, and one that should not be too much to expect of a driver every week. Engineers are giving much attention to simplifying chassis lubrication to such a point that the average vehicle operator cannot object to the time necessary for this important matter.

Summary

The examples of failures which have been described, and the evident resulting expense as well as idle time required for replacements, should drive home vividly the folly of neglecting the lubrication of even a good motor vehicle in spite of having used good lubricants. The serious damage caused by loss of lubricant through leakage, the increased wear resulting from abrasive particles which inevitably get into lubricating oil, as well as the loss of lubricating properties due to dilution from fuel, have been emphasized in detail, and remedies suggested, particularly that of changing the lubricant at suitable intervals. The whole question of precaution for the prevention of premature wear and depreciation is well summarized in the familiar adage, "An ounce of prevention is worth more than a pound of cure."

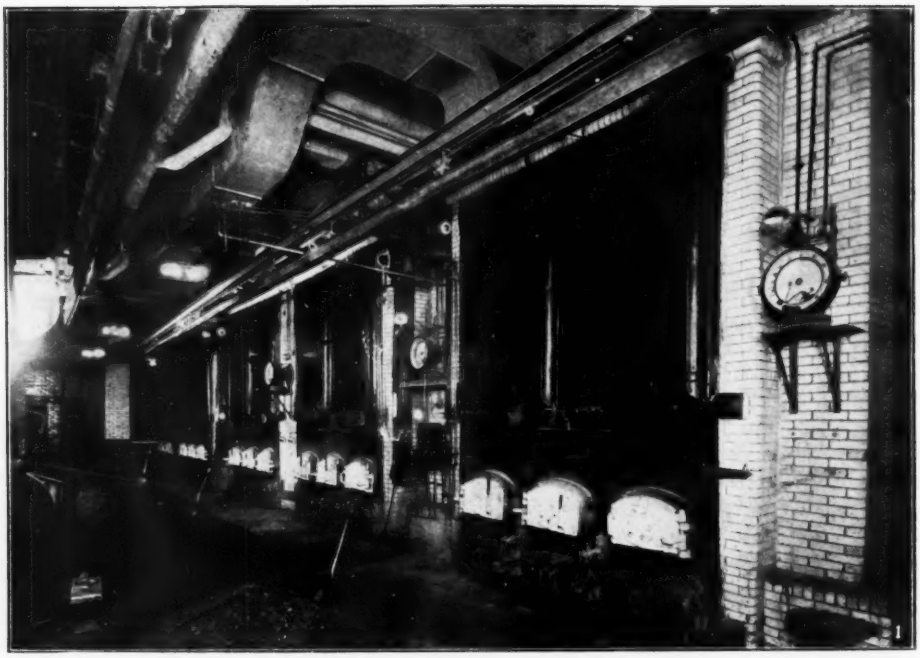


FIG. 1. Fire Room before change was made to oil fuel. Several men were necessary to keep boilers going.

FIG. 2. Fire Room after equipping boilers to burn oil. Notice neat appearance in comparison to previous picture.

Fuel Oil in a Skyscraper

IN the last four or five years a wide market has been established for fuel oil for use on board ships and a large proportion of the ships built by the Shipping Board has been equipped for the use of fuel oil. The internal combustion engine has also played an important part in broadening the market.

New methods of refining whereby a large proportion of the crude formerly coming from the refineries as fuel oil is now refined into gasoline and other higher-priced products, will have a tendency to decrease the supply of oil for fuel. The demand for oil for fuel purposes is more than keeping pace with the production, and only in a few instances during the past three or four years has the supply been greater than the demand.

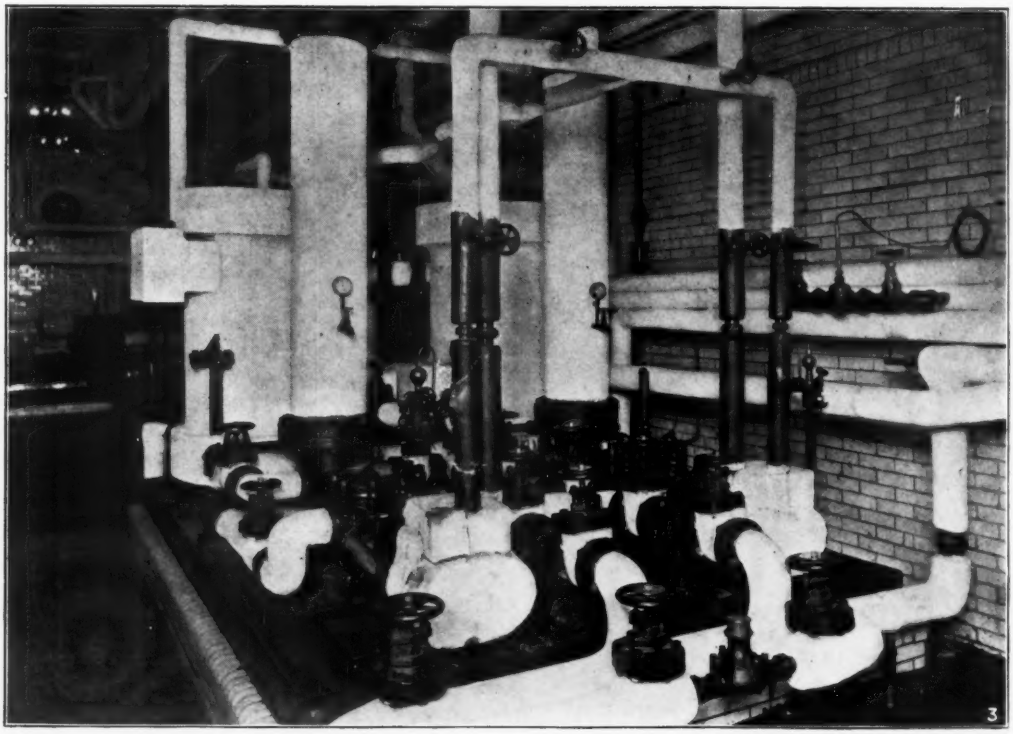
There is every indication, however, that with new fields of production opening up, new transportation facilities and adequate equipment available for handling very much larger quantities, any reasonable demand can be promptly supplied by well-established companies.

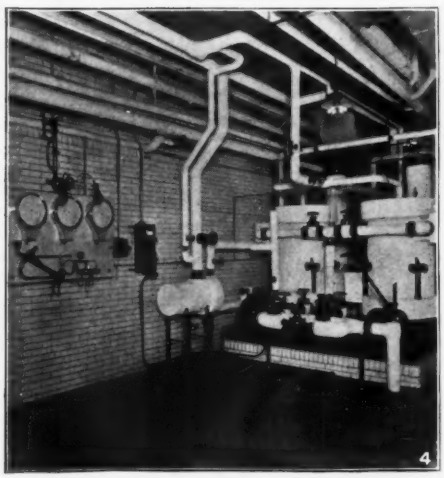
The largest consumption of fuel oil being in plants or operations where coal can also be used leads to the conclusion that fuel oil generally speaking must compete with coal in price, although there are many advantages in connection with the burning of fuel oil as compared with the burning of coal which must be considered in figuring out the actual cost of operations.

The many advantages of the use of fuel oil on ships and its successful application to many factories, have naturally raised the question of its applicability to large office buildings and possibly apartment houses and private homes. Seeing these many advantages the owners of the Singer Building, 145-149 Broadway, New York, determined to burn oil in the power plant in that building. When, however, application was made to the proper city authorities for a permit for this installation it was found that there were no regulations for the storage and burning of liquid fuel under these particular conditions, where safety was primary and efficiency and first cost secondary. Representatives of the various oil companies, burner and boiler manufacturers, and the owners of office buildings were called in for consultation, and a set of regulations were drafted that made the use of oil in city buildings as safe a proposition as that of coal, without any of the disadvantages of the latter fuel. As the details of this installation were considered so completely in order to make it as foolproof as possible, we will give our readers the benefit of the work done, by describing the equipment at this plant. The installation consists of storage tanks, pumps, heaters, burners and such auxiliary apparatus as is necessary in order to make the operation safe as well as efficient.

Storage Tanks

The fuel oil is stored in three tanks varying in capacity from 7,000 to 12,000 gallons. Two of these tanks are located under the sidewalk in the space formerly used for coal bunkers. The remaining tank is installed in a near by room. These tanks are made from $\frac{3}{8}$ inch boiler steel, with double riveted lap joints, rivets spaced $2\frac{1}{2}$ inch centers. All plates are beveled sheared and caulked and were tested to a hydrostatic pressure of 35 lbs. to the square inch. Each of the tanks is enclosed in a separate fireproof vault having masonry 12 inches thick. The walls of the vaults are made water and oil tight by the use of hydrolithic cement. On the top of each tank is a concrete slab 12 inches thick, so designed as to maintain a live load of 300 lbs. per square foot. This top slab is two feet below the underside of the sidewalk construction so as to allow plenty of room for getting into the man-holes situated in the slab. One man-hole in the slab is directly over the man-hole in the tank, from which a ladder drops to the interior of the tank. Another man-hole in the slab allows entrance by means of a ladder to the vault surrounding the tank. The tanks are placed in these vaults on structural steel supports and a clearance of at least 12 inches is allowed all around the tanks. As it was desired to be able to burn almost any grade of fuel oil, provision had to be made for heating the oil in these tanks, in order that it could be pumped. This was done by means of hot water circulating in coils placed within the tank. The water used for this purpose is heated in a separate heater either by exhaust or live steam. An electrically driven pump is used for circulating the hot water through the coils. As a safety proposition in case of fire, along the inside of the top of each tank is placed a pipe drilled with a large number of $\frac{1}{16}$ inch holes and so connected to the steam plant that any fire could be instantly smothered by steam from the boiler. In this connection it may be also said that the vaults in which the tanks set can be flooded by means of a standard fire connection above the sidewalk, for use in case of fire. The tanks are filled by means of a filling box placed in the sidewalk and connected to a system of piping which acts as a manifold.





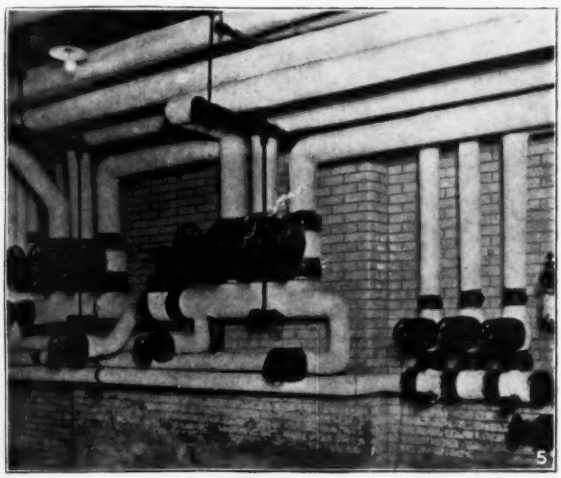


FIG. 3. Closeup showing pumps, air chambers and heaters. Notice the net work of piping and valves to give elasticity to the plant.

FIG. 4. Closeup of oil heaters. Large white cylinders are final oil heaters. Small horizontal cylinder in center of picture is heater for hot water to be used in storage tanks. Gauges for recording temperatures and pressure shown on wall. Notice hand pump in front of one heater, to be used in starting up, or emergency.

FIG. 5. Manifolds from high and low suction lines and also transfer lines.

FIG. 6. Tank truck making delivery to intake manifold beneath the sidewalk. Power pump beneath tank.

This pipe is so equipped with valves that either one tank or the whole battery may be filled at one time if necessary. The filling box can be locked so nothing can be run into the tank without the knowledge of the Chief Engineer.

A 4-inch vent line runs from each tank to a general vent 8 inches in diameter, which leads to the roof of the building. At the top of this vent pipe is placed a goose-neck covered with a fine wire screen to prevent any explosion emanating from the outside. Each vault is also vented to the street to prevent a possible accumulation of vapors. Each tank is equipped with one high and one low suction pipe, and at the end of each is a foot-valve so designed as to prevent any siphoning action taking place when the pumps are not operating. This type of foot valve requires 11 inches of vacuum before the oil will pass through it. The high and low suction pipes lead to separate manifolds which are so cross-connected and equipped with valves that the oil can be drawn at will from either the top or the lower portion of any tank. Each tank is also equipped with a separate line leading to a manifold which is so cross-connected that oil can be pumped from one tank to another if desirable. Installed in each tank is a neumericator which indicates the quantity of oil in each at any time. The instruments for this apparatus are placed on a control board in the boiler room.

Pumps

The oil is pumped from the tank through the heaters to the burners by means of duplex pumps installed in duplicate. To each pump is connected a separate air chamber 10 inches in diameter and 60 inches high. These air chambers equalize the pressure so as to eliminate all pulsation to the burners due to the action of the pumps. There is also a duplicate set of oil strainers. The pumps, air chambers, strainers and heaters are so cross-connected, by-passed, and equipped with necessary valves that oil can be pumped through either pump, air chamber, strainer and heater independently of the other. At the same time the other combination may be used for pumping oil between tanks. This allows either pump, strainer or oil heater to be cleaned without interruption of the service. It also allows by-passing if necessary or expedient. All valves are so marked as to eliminate as much as practical the danger of making improper connections.

Oil Heaters

The oil is pumped through oil heaters to the burners. These heaters, operating by either exhaust steam or that direct from the boiler, are in duplicate, each having a capacity of heating 4,000 pounds of oil per hour from a temperature of 90° F. to 300° F. Each heater is equipped with relief valves both for steam and oil, thereby eliminating all dangerous pressures if the same should materialize. These relief valves are so connected that when dangerous pressures arise, the steam supply to the pumps is cut off, thereby shutting down the system and keeping it within proper operating limits. Should these relief valves fail to work there is another valve which acts as an automatic cut-off. The oil heaters may be by-passed through oil strainers to the main line supplying the burner, if found expedient. The entire pumping apparatus is placed in a cast iron pan flanged 3 inches high and situated on a concrete foundation. The flanged pan prevents such oil as may leak from the pumps getting onto the boiler room floor.

The heater which furnishes the hot water to the coils in the storage tanks, operates either on exhaust or live steam, and is equipped with an electrically driven pump for forcing the water through the coils. In the oil suction line there is installed a thermostatic control apparatus which cuts off the hot water from any individual tank in the event that the temperature of the oil in that tank exceeds that which is required. The temperature of the oil coming from the storage tanks is determined by means of thermometers at the oil end of the pumps and again in the main discharge line to the burners. Meters are installed both in the suction line and in the discharge line from the burners. The amount of oil consumed is determined by the difference in the readings of these two meters, taken at the end of every 8-hour shift. These meters are by-passed so that there will be no break in the flow in case either one should fail.

Supply Lines and Burners

The main supply and return oil lines, from the pumping equipment to the boilers, are laid within a concrete trench 12 inches wide, and protected with cast iron covers. The only openings in these covers are two in front of each boiler. The supply line to the burners rises through one of these openings in front of each boiler vertically to a horizontal pipe across the top of the burners about 4 feet above the floor. Lines drop from this horizontal pipe to the three burners installed in the front of each boiler. At the end of this horizontal line, a return line goes back into the trench to the general return line, and the oil not used in the burners is returned to the suction end of the pump. In this line are installed a pressure-gauge and a thermometer.

The supply to each burner is governed by a gate valve in the burner line. Back of each burner is also installed a special safety valve. The function of this valve is to automatically cut off the supply of oil in case the burner becomes damaged or the special flexible tubing leading to the burner breaks. This tubing is tested to 600 pounds per square inch pressure, but as it is exposed and may become damaged, this special safety valve above mentioned is installed as an extra precaution.

The burners are of the mechanical type with a nozzle orifice .07 inch in diameter. The air is admitted around each burner, and is controlled by sets of vanes located around the circumference of drums at the front end of the fire box. Sets of stationary blades with warped surfaces give the entering air a rotating and whirling motion, thereby increasing the efficiency of atomization and giving better combustion. The draft is natural and is regulated by a damper in the up-take. Both this damper and the vanes in the front of the boiler are so balanced and arranged that in case of an explosion with the fire chamber, the up-take damper will open wide and the front vanes will close, throwing the force of the explosion up the chimney and not into the boiler room.

Boilers and Accessories

The boiler plant consists of 5 B. & W. units, 4 of which are 320 H. P. and the other 160 H. P. The four 320 H. P. boilers are equipped for burning oil, while the 160 H. P. unit is retained for burning rubbish. All these boilers are equipped with automatic water regulators which keep a constant water level in each boiler. They are also equipped with steam flow meters in order to show steam flow and horse-power developed in each case, and also have individual draft gauges that a constant watch may be kept on the draft of each unit. All boilers are connected to a recording CO_2, apparatus by which the composition of the gases generated in each boiler is determined, from which knowledge the excess heat losses can be eliminated. The recording portion of this apparatus and also gauges for recording steam pressure are located in chief engineer's office.

In the boiler room are installed three recording indicators, two for temperature and one for pressure. The first gives a record of the preheat temperature of the oil at all times. The second gives a record of the pressures of the oil delivered to the burners. The third shows the temperature of the oil at the suction of the pump at all times.

All piping, heaters, pumps, etc., are covered with magnesia pipe covering and canvas in order to reduce the heat losses to a minimum and give a neat appearance to the installation.

Oil Delivery

The oil is delivered to the storage tanks by means of large tank trucks having a capacity of 1,800 gallons each. These tank trucks are equipped with pumps for unloading the oil, which can be done from either side of these trucks. Connection is made by means of a flexible hose to the inlet pipe of the filling box. The 1,800 gallon tank can be unloaded by this system in approximately 10 minutes. The temperature of the oil when delivered is approximately 110° F.

Summary

We have given above a description of an oil burning installation in which extra precautions, much above those ordinarily required, have been taken to provide safety. While this was the first consideration, it was found that such a safety installation could be made without loss of efficiency. The flexible layout of piping and connections affords every facility for continuous operation and proper care. The result has been that this plant has operated continuously with no interruption due to faulty installation or imperfect precautions. As this is one of the first installations of its kind in New York City, the engineers who designed this plant are to be congratulated on its successful operation and neat appearance.

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It meant that I was obliged to take whatever grade of oil I could find at the nearest station, provided of course, that there was a station near the point where I first noticed the shortage of oil.

Now, as I said, I have an Easy Pour Can in my car all the time. I am never stuck on the road for want of oil. Whenever I need oil, all I have to do is to take out my Easy Pour Can, screw off the cap, punch the seal, put the nozzle of the can to the filler pipe, and pour out as much oil as is needed to bring the oil in the crank case up to the proper level.
If it so happens that I need two quarts, I throw away the empty can and am ready to drive on without stowing away an oily funnel.
Sometimes I need less than the full contents of the can, in which case I screw on the cap tightly, and keep the remaining oil for the next occasion.
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